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TECHNICAL REPORT - NAVTRADEVCEM 495-8-1

STUDY OF THE PRESENT STATUS OF TRAINING AIDS AND  
DEVICES IN THE ARMY FIELD ARTILLERY TRAINING PROGRAM

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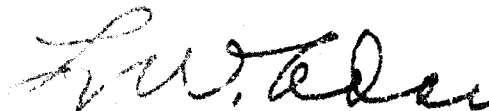
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## FOREWORD

### Purpose

Training aids and devices have proved useful in a wide variety of training situations. This project had as its objective an investigation of training in Army Field Artillery with reference to aids and devices.

The Artillery and Guided Missile School, Fort Bill, Oklahoma was the basic source of data for this study. The research was conducted by The Ohio State University Research Foundation under contract to the U.S. Naval Training Device Center.

The subject matter of this study was restricted to the following artillery operations:

- (1) Conduct of observed fire,
- (2) Fire Direction Center,
- (3) Flash and sound ranging.

The training device recommendations growing from this study have as their purpose the reduction of time and costs and the increase of training effectiveness.

Training areas warranting device development were objectives, skills and knowledge to be taught. The training device section of the recommendations section of the report is based on a study of these device areas.

This information is being developed, pending endorsement, in the device specifications.

tion of the  
training programs involved. Such implementa-  
tions increase training costs and increase the effectiveness  
of effort.

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## RECOMMENDATIONS

From the results of the study herein reported, the development of five devices is recommended. These devices were conceived for the purpose of developing an optimal combination of the following objectives: (1) increasing training effectiveness, (2) reducing training time, (3) decreasing training ammunition expenditures, and (4) decreasing training costs in facilities, school troops, and instructors. The devices are applicable to training in (1) conduct of observed fire, (2) flash ranging, and (3) sound ranging. Complete descriptions of the functional characteristics of these devices appear in the technical appendices.

### I. Basic Visual Skills Trainer:

A. A device should be designed to train for the basic visual skills involved in the conduct of observed fire and in flash observation.

1. In Job terms, the objectives of this device are:

- a. to make the trainee more effective in detecting and identifying enemy targets
- b. to make the trainee more effective in determining the exact location of enemy targets
- c. to make the trainee more effective in making estimations of distance
- d. to make the trainee more effective in remembering the details presented in his zone of responsibility.

2. In terms of underlying skills, it is the function of this device to improve: (a) form perception, (b) the extent of the observer's form field, (c) visual location, (d) visual memory, (e) visual discrimination, and (f) perception of distance.

### II. Forward Observer Trainer-Assessor:

A. A device should be developed to provide practice in the skills involved in the job of forward observer, to provide an objective measure of overall job performance, and to provide a validation instrument for training given in

basic visual skills. This device should simulate those conditions in the actual field situation that significantly bear on the skills involved in the job.

1. The objectives are:

- a. to provide a realistic situation for the integration of the basic skills involved in the job
- b. to provide practice in acquiring and dealing with enemy targets
- c. to develop and allow for the application of efficient procedure and skills of map utilization
- d. to provide objective measures of job performance
- e. to provide a validation instrument for basic visual skills training

III. Flash Observer Trainer-Assessor:

- A. The device should provide a situation where the flash observer may practice the major operations in his job - searching for, acquiring, and identifying targets. Principal emphasis is to be placed on detecting cues revealing the presence of enemy artillery.

1. The objectives are:

- a. to require the observer to employ the basic techniques of visual search
- b. to present targets of various types, numbers and difficulty
- c. to provide a means of checking the observer's response
- d. to provide objective measures of job performance
- e. to provide a validation instrument for basic visual skills training.



#### **IV. Sound Outpost Observer Trainer:**

- A. A device should be developed to provide training in the critical skills involved in the job of outpost observer. The device should be capable of presenting training materials in a basic perceptual skill training program, and/or in a combat simulated setting.**

**1. The objectives are:**

- a. to develop skill in judging the azimuth and range of various sound sources**
- b. to develop skill in identifying or estimating the calibre of a gun fired**
- c. to develop skill in distinguishing between ballistic waves, muzzle waves, or shell bursts**
- d. to develop, when used in a combat simulated setting, skill in selecting targets that have a high probability of being located by sound ranging methods**
- e. to provide objective measures of job performance**
- f. to provide a validation instrument for basic auditory skills training.**

#### **V. Sound Record Reader Trainer:**

- A. A device should be developed capable of producing a graded series of sound tapes for training uses.**

**1. The objectives are:**

- a. to develop and reproduce a series of sound tapes from those easily read to highly complex ones to be used as training materials**
- b. to permit the reproduction of a graded series of tapes for use at installations which are without the means of producing such a set of training materials**
- c. to permit the development of sound tapes using the guns of potential enemies**

- d. to permit, if desired, the development of sound tapes made in coordination with materials developed for the outpost observer trainer, thus permitting the integration of training for these two jobs
- e. to provide objective measures of performance in the critical aspects of the job.

## BRIEF OF THE STUDY

### I. Introduction

A requirement exists for the development of aids and devices to support training in the following field artillery subjects: (1) Conduct of Observed Fire, (2) Fire Direction Center Operator, (3) Flash Ranging, and (4) Sound Ranging. The objective of the research reported here was to isolate those aspects of the human task which are critical factors for training, and to state these critical factors in terms of training device requirements. Later research will consist of the development and testing of devices to meet these requirements. Such devices optimally would provide (1) increased training effectiveness, (2) reduced training time, (3) decreased expenditures of training ammunition, and (4) decreased costs for training facilities and personnel.

The field study phase of the research was conducted at the Artillery and Guided Missiles School, Fort Sill, Oklahoma. Within the school, research activities were centered largely in the departments of Gunnery, Observation, and Tactics and Combined Arms. Courses with which the research staff was concerned include (1) Artillery Officers' Basic Course, (2) Officers' Advanced Course, (3) Officer Candidates' Course, (4) Artillery Flash Ranging Supervision Course (Enlisted), (5) Artillery Sound Ranging Supervision Course (Enlisted) and (6) Artillery Observation Officers Course.

### II. Method

The investigation of each of the four job areas involved four phases: (1) analysis of the job, (2) analysis of training for the job, (3) determination of the basic psychological skills involved in the critical job requirements, and (4) specification of the functional characteristics of devices to support the training. The remainder of this section of the brief presents the essential procedures of these four phases.

#### A. Analysis of job

The purpose of the job analysis was to isolate the critical elements of each job. A job element was judged critical if it (1) is vital to the successful completion of the job, and, either (2)

demands a highly developed or complex skill, or (3) is often performed below specified standards.

The first step in the job analysis was to review pertinent technical literature in each of the four job areas. Field manuals and the Artillery School lesson plans were the major sources of information. This review provided a detailed description of job objectives, equipment, activities, and performance conditions.

The second step was to observe the jobs being performed under the most realistic conditions available. All such field observations were made during service practices and field problems. These observations, supplemented by interviews with students and instructors, led to preliminary judgements concerning critical job elements.

The third step in the analysis was to interview personnel with combat experience in the four jobs. These interviews provided information concerning conditions which prevailed in the "real" or combat situations. The special requirements imposed by combat resulted in modifications and additions to the lists of critical elements. The end product of the job analyses was a list of job requirements which met the stated criteria of criticalness and constituted critical requirements for training.

#### **B. Analysis of training**

Observations were made of those portions of the courses listed in the introductory section which were judged most relevant to the jobs under consideration. Students were followed through the sequence of instruction leading to the job performance, and through the series of accompanying field exercises. Instructional methods, training devices, practical exercises, field problems, and sequence of presentation were all examined with reference to possible device implementation. Particular attention was given to the development of those skills judged to be critical in the job analysis. The observations were supplemented by informal interviews with instructors, students and administrative staff.

The result of the training analysis was the isolation of those portions of the courses where device implementation appeared most promising. Also, consideration was given to the possible utilization of devices by those installations whose facilities were more limited than those of the Artillery and Guided Missiles School.

### C. Basic psychological skills

As a result of the job analyses and training analyses, a list of job requirements was determined which met the imposed criteria of criticalness and which constituted training problems. In terms of the psychological information available concerning these kinds of performances, basic psychological skills were abstracted from this list.

### D. Device solutions

The final phase of the research consisted of developing the functional characteristics of devices which would contribute to the attainment of a better training product. Functional characteristics are stated as follows:

1. The purpose of the device and the specific skills which are to be developed.
2. The nature of material presented to the trainee by the device, and the manner (but not the means) of presentation.
3. The responses required of the trainee which are to be measured and recorded.
4. Suggested utilization of the device in training.

## III. Overview of the Jobs

### A. Conduct of observed fire

The purpose of conduct of fire is to bring effective fire on a target by adjusting with observed rounds. Normally, conduct of fire is comprised of the following sequence of activities.

1. A forward observer occupies an Observation Post (OP) near the front lines. The OP is connected by radio and wire to the Fire Direction Center (FDC), and is located to allow the best available view of the front. The forward observer maintains a constant surveillance of his zone of responsibility, searching for signs of enemy activity and remunerative targets.

2. When the observer detects a target he (a) identifies it, and (b) determines its location by one of three commonly used methods.
3. Using a standard reporting procedure, the observer relays this information to the FDC in the form of a request for fire mission, including the type of adjustment, ammunition, fuze, and method of control to be employed.
4. At the FDC, this information is processed, and converted into firing data for the guns (see Fire Direction Center Operation). If the mission is to be fired, FDC signals the observer to that effect and indicates when each round (or volley) is on the way.
5. The observer senses the location of the bursts of the rounds respective to the adjusting point. Determination is made of deviation (in yards) in range, azimuth, and, if time fuze is used, height of burst in yards. The observer calls the subsequent corrections to the FDC, where modifications in the firing data are computed for the following round.
6. When the rounds burst on the observer target (OT) line, and the adjusting point has been inclosed in a 100 yard range bracket, the observer calls for "Fire for Effect." When the target has been neutralized, the observer requests the FDC to end the mission.

#### **B. Fire direction center**

Briefly, the purpose of a fire direction center is to provide a commander with fire control. It is the agency which translates target intelligence, fire missions from higher commanders, and requests for fire into a usable form and transmits them to the guns. Targets and requests for fire are reported to the fire direction center where they are plotted on a firing chart. From this plot, data in a proper form are prepared and relayed to the batteries as fire commands.

The fire direction center (battalion) is organized and supervised by the battalion S3. In this organization, at present, is an assistant battalion S3, operations sergeant, horizontal and vertical control operators, computers, and telephone and radio operators. Thus, a fire direction employs a team involving several jobs. These

may be briefly described as follows:

1. The S3 plans, coordinates, and supervises the activities of the fire direction center, and trains the personnel.
2. The assistant S3 is the relief and replacement for the S3.
3. The horizontal control operator (HCO) constructs and maintains firing charts, operates the target grid, prepares, when necessary, a range deflection fan, constructs deflection index and deflection-correction scale, plots targets, and determines and announces data.
4. The vertical control operator (VCO) maintains a chart identical to that of the HCO. For fire missions, the VCO determines the site for each battery. The VCO is the relief for the HCO.
5. The computers (one per firing battery) convert S3 orders and HCO and VCO data into fire commands which are transmitted to the batteries. Their jobs involve recording, computing, announcing commands and corrections, and alerting the battery of an impending fire mission.

#### C. Flash observation

The purpose of flash observation is to locate targets, principally enemy artillery, in a given sector of responsibility. There are two basic elements in the flash observation system: (1) a flash base comprised of two to four observation posts (OP's), and (2) a central station called plotting central. The OP's are emplaced in surveyed positions commanding the best available view of their sector of responsibility. They are connected by wire and radio with plotting central. The system operates as follows:

1. A flash observer occupies each OP, and maintains surveillance of his sector of responsibility. Artillery, although usually hidden, is often revealed by the flash, smoke or dust which accompanies firing. The observer utilizes such cues to detect the presence of enemy artillery.
2. When a target is detected, the observer adjusts his viewing instrument (M2) to center the target (or its probable location) in the optics.
3. From the scales on the viewing instrument, the observer obtains an azimuth and elevation reading from the OP to the target.

4. Following a standard procedure, the observer reports this information to plotting central, giving an estimate of the probable accuracy of his data.
5. Plotting central, using the reported azimuths to the target from each of the OP's, computes the probable location of the target by means of a plotting table and a simple geometric solution. This information is forwarded to a Corps Headquarters for further action.

Targets other than enemy artillery are frequently located by the same basic procedure. Additionally, the flash observers at each OP may operate independently as forward observers in adjusting friendly artillery fire. In the latter case, they perform the same operations as the forward observer discussed in III, A.

#### D. Sound ranging

The primary mission of the sound ranging platoon is the location of hostile artillery. Various jobs within the sound ranging platoon contribute to the successful accomplishment of this mission.

For two of these jobs, factors were isolated which seemed to indicate need for device solutions. These two jobs were (1) outpost observer, and (2) sound record reader.

##### 1. Outpost Observer

The outpost observer occupies an OP at least two sound seconds (at least 675 meters) closer to the locations of hostile artillery than any microphone in the sound base he activates. In addition, the OP is selected to provide good visual observation of the enemy area, concealment, and to minimize the disturbing sounds of friendly artillery and small arms fire.

The outpost observer is responsible for constant surveillance of his zone. He listens for the sounds of enemy guns or friendly shell bursts which the sound platoon can profitably record, analyze, and locate. He is responsible for starting the sound recording set and stopping it when directed to do so. In addition to activating the sound recording equipment, the outpost observer provides sound ranging central with important information in regard to the sound he has singled out for location. This includes (1) the probable azimuth of the sound source heard, (2) his estimate of the range to the sound source heard, and (3) his identification or estimate of the calibre of the enemy gun he has heard. This information from the outpost observer is important to the sound record reader in enabling him to identify the "pattern of arrivals" of sound waves at the various microphones and consequently leads to a more reliable target location.



## 2. Sound Record Reader

When the outpost observer selects a sound for analysis by sound ranging methods, he signals the operator of the sound recorder. The sound recorder produces a tape which records the arrival time of the sound at the various microphones in the sound base. A pattern of arrivals is thus produced on the tape. In addition to the arrival time of the sound at each microphone, the recorder produces a record of the characteristics of the sound in terms of amplitude, frequency, and wave composition. This record (tape) is turned over to the sound record reader for analysis and interpretation.

Selection of the desired pattern of arrivals (breaks) is the first step in reading a record. If there is only one pattern, this is a simple task. When there are several sounds recorded on the tape, and consequently several patterns, the reader must visualize the desired pattern in order to isolate it from other patterns. Having isolated a pattern for study, the record reader then attempts to determine the time of the initial break for each trace; a trace will appear on the sound tape for each microphone in the sound base.

The problem of determining the initial break in each trace is complicated by the fact that various conditions such as wind interference affect the styli that produce the traces. When initial breaks cannot be identified, other points on the wave form are used; these commonly are first valleys, first peaks, and zero lines of the wave forms.

After a set of arrival times has been determined for a given sound, the record reader has the task of inspecting the wave forms selected, to interpret them, and extract information. He attempts to judge the calibre of the gun firing from the wave amplitude and frequency. He attempts to distinguish the wave forms of different types of guns. He must be sure he hasn't selected ballistic wave forms or the wave forms produced by shell bursts; these need to be distinguished from muzzle waves.

## IV. Results and Conclusions

The major outcome of the present research was the development of the functional characteristics of the five training devices recommended as possible solutions to the observed training problems. These device characteristics are outlined in the Recommendations section of this report and appear in detail in the Appendices.

Tables I, II, and III summarize the relevant information obtained for the jobs of the forward observer, flash observer, sound outpost observer, and sound record reader respectively. The critical job requirements and their ratings on each criteria of criticalness are presented along with the underlying psychological skills; these in turn are related to the training device which is suggested to implement their training.

No table is presented for jobs of the personnel in the fire direction center. Observations were made, and the jobs studied, of those personnel used in fire direction center. Attention was directed toward those jobs in which the training needed might be aided through device development. These were the jobs of horizontal control operator, vertical control operator, and the computers.

Briefly, the jobs were largely ones which involved procedural knowledge, plotting and drawing accuracy, computational skills, record keeping, the operation of devices such as a target grid and deflection fan, and the announcing of results. Several of the elements of these jobs require familiarization and use of operational equipment. No training device supplementation appeared warranted. Other elements such as computational skills, procedural knowledge, record keeping, and announcing the results similarly suggested no need for training device support.

TABLE I

This is a summary table of (1) the critical job requirements in forward observation warranting device support, (2) the basic psychological skills underlying these requirements, (3) the criticalness of the skills, and (4) the recommended devices for development of the skills.

Job requirement	Basic psychological skill	Criteria of criticalness			Device Recommended
		Crucial	Complex	Substandard	
1. Acquisition of artillery targets	Perception minimal changes; memory for complex visual stimulus	yes	yes	not observed <sup>1</sup>	1. Trainer basic visual skills 2. F.O. trainer assessor
2. Identification of targets	Form perception	yes	yes	not observed	" "
3. Memory for terrain detail	Memory for complex visual stimulus	yes	yes	not observed	" "
4. Estimation of observer-target distance	Translation of available cues into distance estimation	yes	yes	yes	" "
5. Sensing burst deviations - speed and accuracy	Spatial location of a visual stimulus at onset and retention of location despite subsequent distortion	yes	yes	yes	" "
6. Map reading - locating targets and other relevant points	6. <sup>2</sup>	yes	yes	yes	F.O. trainer assessor

TABLE I (continued)

Job requirement	Basic psychological skill	Criteria of criticalness			Device Recommended
		Crucial	Complex	Substandard	
7. Map reading - terrain evaluation and visibility and sketches	7.2	yes	yes	yes	F.O. trainer assessor
8. Judgment of fire requirements for specific situation	Translate a complex visual stimulus into a specific action requirement	yes	no	not observed	F.O. trainer assessor
9. Sensing "own" rounds - discriminating between bursts of different weapons	Discrimination between apparently similar visual stimuli	yes	yes	not observed	1. Trainer basic visual skills 2. F.O. trainer assessor
10. Familiarity with different types of terrain	Integration of terrain into the development of visual skills	yes	yes	not observed	F.O. trainer assessor

<sup>1</sup>These items were either not available for observation or too few instances were available to permit a reliable judgment.

<sup>2</sup>The basic skills have not been satisfactorily isolated.

TABLE II

This is a summary table of (1) the critical job requirements for the Flash Observer warranting device support, (2) the basic psychological skills underlying these requirements, (3) the criticalness of these skills, and (4) the recommended devices for the development of the skills.

Job requirement	Basic psychological skill	Criteria of criticalness			Device recommended
		Crucial	Complex	Substandard	
1. Acquisition of targets	Perception of stimuli in a complex visual field Localize in space visual stimuli of short duration	yes	yes	yes	1. Trainer basic visual skills 2. Flash observer trainer assessor
2. Identification of targets	Identification of typical target objects through form perception	yes	yes	not observed <sup>1</sup>	"
3. Estimating distance to targets	Translating available cues into estimations of distance	yes	yes	not observed	"
4. Reading scales of the M2 observing instrument	Retention of the details of a complex visual stimulus after short exposure	yes	yes	no	Flash observer trainer assessor
5. Adjusting M2 observing instrument to center target	Perform fine perceptual motor tasks	doubtful	yes	no	"

TABLE II (continued)

Job requirement	Basic psychological skill	Criteria of criticalness			Device recommended
		Crucial	Complex	Substandard	
6. Map reading - locating reference points, preparing visibility sketches, range estimation and terrain evaluation	6.2	yes	yes	no	Flash observer trainer assessor
7. Employing efficient search techniques to cover sector of responsibility	Efficient utilization of observers form field	yes	yes	yes	Trainer basic visual skills Flash observer trainer assessor

<sup>1</sup>These items were either not available for observation or too few instances were available to permit a reliable judgment.

<sup>2</sup>The basic skills have not been satisfactorily isolated.

TABLE III

This is a summary table of (1) the critical job requirements in sound ranging warranting device support, (2) the basic psychological skills underlying these requirements, (3) the MOS requiring these skills, (4) the criticalness of the skills, and (5) the recommended devices for the development of the skills.

Job requirement	Basic psychological skill	MOS aided by device	Criteria of criticalness			Device recommended
			Crucial	Complex	Substandard	
1. Judging the direction (azimuth) of various sound sources	Sound localization	Outpost observer	yes	yes	not observed	Sound outpost observer trainer
2. Judging the range of various sound sources	Sound localization	"	yes	yes	"	"
3. Estimating or identifying the calibre of an enemy gun	Auditory discrimination	"	yes	yes	"	"
4. Distinguishing between various sounds such as are produced by ballistic waves, muzzle waves, or shell bursts	Auditory discrimination	"	yes	yes	"	"

TABLE III (continued)

Job requirement	Basic psychological skill	MOS aided by device	Criteria of criticalness		Device recommended
			Crucial	Substandard	
5. Selecting profitable targets for analysis by sound ranging methods	Judgment	Outpost observer	yes	yes not observed <sup>1</sup>	Sound out-post observer trainer
6. Distinguishing the wave forms produced by ballistic waves, shell bursts, and muzzle waves	Visual discrimination between similar stimuli	Sound record	yes	" "	Sound record reader trainer
7. Identifying and locating breaks in sets of traces	Identification of stimulus component	" "	yes	" "	" "
8. Visualizing the pattern of arrivals from information given by the outpost observer	Visualization	" "	yes	" "	" "



TABLE III (continued)

Job requirement	Basic psychological skill	MOS aided by device	Criteria of criticalness		Device recommended
			Crucial	Complex	
9. Visualizing the approximate wave form from information given by the out-post observer	Visualization	Sound record	yes	yes	not observed <sup>1</sup> Sound record reader trainer

<sup>1</sup>These items were either not available for observation or too few instances were available to permit a reliable judgment.

## **TECHNICAL APPENDIX**

**APPENDIX 1: CONDUCT OF OBSERVED FIRE \***

**APPENDIX 2: FLASH OBSERVATION**

**APPENDIX 3: SOUND RANGING**

## APPENDIX 1: CONDUCT OF OBSERVED FIRE

### I. Analysis of the Job of Forward Observer

#### A. Job description

The purpose of conduct of fire is to bring effective fire to the target by adjusting observed rounds. For close support missions, the field artillery is dependent largely on the forward observer as the man responsible for controlling this adjustment.

The forward observer occupies an observation post (OP) near the front lines, which permits the best available view of his zone of responsibility. He is responsible for constant surveillance of this zone, searching for remunerative targets. When enemy activity which warrants artillery fire is detected, the observer must bring accurate fire upon it in a minimum amount of time. This involves several steps. First, the observer must locate the target for the fire direction center. His location may be in terms of (1) military grid reference, (2) polar coordinates, or (3) reference to base point, check point, previous concentration, or center of sector. After locating the target for his own purposes, the observer calls for a fire mission; the call containing (a) the observer's identification, (b) location of target, (c) nature of target, (d) type of adjustment, (e) type of ammunition, (f) fuze action, and (g) method of control. The fire direction center will in time signal the observer that the mission is being fired, and that a round is on the way. The observer then attends to the target area and makes a sensing of the round at its point of burst. Sensing is the determination by the observer of the location of a burst or group of bursts with respect to the adjusting point. The observer measures the angular amount in mils that the burst appears off the observer-target (OT) line, measures the height of burst in mils if time fuze is being employed, and makes a range sensing (over or short) whenever a burst is close enough to the OT line to allow such a sensing. Subsequent corrections are based on these sensings. In adjusting for height of burst and azimuth deviations, the WORM rule (width over range equals mils so range times mils equals width in yards) is applied. The OT distance (in thousands of yards) is multiplied by the measured deviation in mils. This becomes the correction to apply for the next round. If a round is sensed as Right of the target, the correction, of course, must be Left X number of yards. The adjustment of range has as its objective the splitting of successively smaller brackets (one round OVER, one round SHORT, constitutes a bracket) until a 100 yard bracket is obtained. Fire for effect will begin at the center of this 100 yard bracket.

The above description provides a view of the forward observer's job, narrowly conceived. Its focus is restricted to the acquisition of a target, and the bringing of fire into the effective zone. This view ignores situational variables which may be of importance. Such a view, however, has the advantage of pinpointing those activities most directly concerned with the primary mission of the observer. Below are summarized the major job requirements for the Forward Observer. Those requirements directly concerned with the immediate accomplishment of the forward observer's job are listed as Group I requirements, while those concerned with the broader aspects of the job are listed as Group II requirements.

**Group I requirements - The forward observer must:**

- (1) Acquire and identify targets, evaluate terrain, estimate distance to the target, sense observed fire, and discriminate between his own and other rounds. These requirements all demand visual skills.
- (2) Utilize a map to locate his own position, pertinent reference points; to locate targets for initial computation of data, and in general evaluate the terrain.
- (3) Know the communication procedures for conduct of fire - in reporting observations, requesting fire, and adjusting fire.
- (4) Perform simple arithmetical computations in determining the initial data (target location), and in determining corrections in adjusting fire.

**Group II requirements - The forward observer must:**

- (5) Select, occupy, and maintain an Observation Post that will allow him to perform his primary tasks as efficiently as possible.
- (6) Make judgments of the fire requirements for specific targets and specific tactical situations in terms of ammunition fuze, quantity of fire, etc.
- (7) Have a thorough knowledge of the specific situation in which he is operating in terms of the current plan of action and tactics of the supported unit.

- (8) Be familiar with operating in different types of terrain since terrain features greatly affect the performance of all activities listed under (1), above.

#### B. Application of criteria

The major job requirements of the forward observer were examined to determine the extent to which they constitute critical requirements for training. Three criteria of criticalness were developed: (1) the extent to which the job requirement was crucial to the success of the mission, (2) the level of complexity of the skills involved, and (3) the frequency with which the requirement was performed in a substandard manner. A requirement was critical if it were judged crucial and either complex or its performance substandard. Table IV (see page 25) summarizes the application of these criteria to the job requirements.

##### Criterion 1: Crucial to the success of operation

Most of the job requirements listed under Group I, above, are considered crucial to the success of the forward observer's mission. The target, first of all, must be detected before any subsequent action can occur. Correct identification is essential for the safety of friendly forces as well as for determining appropriate fire requirements. Sensing rounds quickly and accurately, and sensing the observer's rounds and not others bursting in the area, also have appreciable effect on the success of the mission since time lost in establishing a bracket may seriously reduce the tactical advantage. The effect of a failure in the procedural sequence would probably not, however, cause a mission failure if the FDC team were competent. Computational errors would produce complete failure only in the case where immediate fire for effect was necessary. Typically, minor computational errors increase the number of rounds required to deliver effect on the target but may also endanger friendly personnel. Poorly developed skill in map reading appreciably reduces effectiveness since it produces extreme initial errors, and poor terrain sensings.

Most of the job requirements listed under Group II, above, although important in the total job complex, are not strictly crucial to the success of the mission. Deficiency in any of the requirements would be most noticed in making the observer's primary tasks (Group I) more difficult to perform. The selection, occupation and maintenance of the OP is probably the most essential task in this group. It is also important that the forward observer be capable of operating effectively in different types of terrain. Visual skills which have been adequately developed in a flat or rolling

terrain may be inadequate for rough or mountainous terrain, thus seriously reducing the quality of the observer's performance. Such inadequacies may best be circumvented by providing the observer, during his training, with a broader experience in acquisition, identification, distance estimating, etc., and it is on this level that the problem is approached in the present research.

#### Criterion 2: A high level, complex skill

Of the Group I requirements, neither procedural knowledge nor computational skills are high level, complex skills. They are simple skills and are normally mastered in a very few practice trials.

Some of the visual tasks are clearly high level skills. The acquisition of a target seems to require that the observer perceive some change in a visual stimulus, that is, the field of observation before him. It must be noted that the stimulus is quite complex, extending over a wide lateral range (perhaps as great as 180°) and considerable depth (maximum range of the zone of responsibility is the maximum range that the observer can see). The nature of his responsibility varies with the range, of course; he normally fires on targets that are from 50 to 5,000 yards distant, and including a variety of figural elements (which may include buildings, streams, trees, knolls, bunkers, etc.) which together constitute "figure." A target may be indicated by (1) an addition to the figure component, as a "tree that was not there yesterday," (2) a change in structure of the figure, as "three bushes that have moved together since yesterday," (3) a deletion from the figure component, as a "lone tree that has disappeared," or (4) a changing figure, as "a tree that is moving as I observe it."

Having perceived a change in the figural component of the visual stimulus, the observer must identify this new stimulus element, the identification involving perception of form. Range estimation is a third perceptual task which is a complex skill. Normal target distance requires that cues of size, perspective, shading, superimposition, etc. be interpreted either in terms of "more than" or "less than" or in terms of a specific number of yards. Precise estimation of range may be made unnecessary by map reading skills.

The same cues are employed in sensing a round as over or short of the target, with superimposition being of maximum importance in the case of line shots. In sensing a round, speed of perception is important for two reasons. First, once a burst has expanded, it may occupy an appreciable lateral distance, making the judgment of center-of-burst difficult. Second, any wind in the target area moves the burst off the original point of impact. Optimally then, the sensing should be made at the instant of the appearance of the burst.

Map reading may also represent a complex skill, though one less well analyzed in terms of behavioral components. The knowledge variable concerning the meaning of symbols, how to measure distance and azimuth, and the representation of contour do not constitute a complex or difficult-to-learn area. Relating this knowledge as presented on a given map to a terrain actually viewed may well be complex. For the Group II requirements, relatively little evidence is available to indicate the level or complexity of the skills involved. However, information from interviews with instructors and combat experienced personnel suggests that these requirements demand neither high level nor complex skills.

### Criterion 3: Substandard performance

Certain of the Group I job requirements were observed to be performed in a substandard manner. Inability to read a map is by considerable odds the most frequently mentioned weakness attributed to students (both beginning and advanced) by faculty and staff at Ft. Sill. It is the most frequently mentioned deficiency on the part of the forward observer experiencing combat for the first time, and it is a weakness commonly applied by senior officers to the present field artilleryman-in-general. Observations confirm this inadequacy on the part of the student, and data gathered on accuracy of initial data demonstrates the prevalence of extreme errors in this task which is essentially based on ability to relate terrain to a map representing the terrain.

It is difficult to ascertain the extent to which the necessary perceptual skills are present in the sample of forward observers available for study. The absence of a suitable criterion measure for sensing rounds makes the testimony of experienced observers open to question. Data gathered indicate considerable discrepancy between experienced observers sensing the same round from identical viewing points. It is quite clear that ability to estimate range, and ability to make maximum use of terrain features in sensing rounds could be improved. No practice in target acquisition was observed; it may be inferred that performance in this area could also be improved.

All requirements listed under Group II were frequently mentioned by interviewees as being performed in a substandard manner. This was especially characteristic of the new forward observer experiencing combat for the first time.

TABLE IV

Table IV summarizes the application of the three criteria of criticality to the major job requirements of the Forward Observer. Starred items are considered critical requirements for training.

Job requirement	Criteria		
	Crucial	Complex	Substandard
* 1.Acquisition of artillery targets	yes	yes	not observed <sup>1</sup>
* 2.Identification of targets	yes	yes	not observed
* 3.Memory of terrain detail	yes	yes	not observed
* 4.Estimation of observer-target distance	yes	yes	yes
* 5.Sensing burst deviations - speed and accuracy	yes	yes	yes
* 6.Map reading - locating targets and other relevant points	yes	yes	yes
* 7.Map reading - terrain evaluation and visibility sketches	yes	yes	yes
* 8.Procedural knowledge - reporting observations, requesting and adjusting fire	no	no	no
* 9.Computation of initial data and corrections	yes	no	no
*10.Judgment of fire requirements for specific situations in terms of ammo. fuze, quantity of fire, etc.	yes	no	not observed
*11.Selection, occupation and maintenance of OP	yes	no	yes
*12.Comprehension of mission - knowledge of current scheme of action and tactics of supported unit	doubtful	no	not observed



TABLE IV (continued)

Job requirement	Criteria		
	Crucial	Complex	Substandard
*13. Sensing "own" rounds - discriminating between bursts of different weapons	yes	yes	not observed
*14. Familiarity with different types of terrain	yes	yes	not observed

<sup>1</sup> These items were either not available for observation or too few instances were available to permit a reliable judgment.

### C. Analysis of training

Observations of the training program for the Officer's Basic Course at Ft. Sill were made, with special attention being given to the critical job requirements (Table IV, pp. 25-26). These observations were supplemented by interviews with the administrative staff, instructors and students. The purpose of the training analysis was to determine the extent and nature of training related to the development of skill in the critical job requirements, and to isolate portions of the program where device implementation seemed most promising.

Requirements 1, 2, and 3 (Table IV) concern target acquisition and identification. No training for these skills was observed. During service practices, various objects (rusty material, beaten-up area, etc.) are located in terms of some reference point by the instructor, and identified variously as "patrol in the open," "stalled tank," "enemy machine gun," etc. It would be impossible to have real target activity during a service practice, of course, and it would be both time-consuming and expensive to have such realistic practice during dry-run sessions on the ranges. Some opportunity is present during the Combined Arms Tactical Exercise, but real limitations are again obvious. No aids or devices which present this experience are currently available. Opportunities for this skill development are greater in post-school training situations, but time and expense would remain as deterrents. An additional difficulty with any practice session in which realistic targets are acquired in the field, is that a valid criterion of performance is extremely difficult to establish. While it is possible to record all activity taking place in a given area, this record will ignore the relative difficulty of acquiring a particular target from a particular observation post; as a consequence, "scores" for observers will not be

comparable, knowledge of results will contain considerable error variance and it will not be possible to chart the progress of the student.

Requirement 4 refers to estimating distance from observer to a target on the basis of the available cues. Service practices provide opportunity to practice this skill. In particular, two service practices are devoted in part to situations where "pure" estimates (made solely on the basis of such cues, without regard to the map) are made. Additional experience is provided in a practical exercise in map reading. There is no instruction given in how to accomplish this task; there is widespread agreement that it is extremely difficult and that very few people can do it. Whenever an individual estimates distance, he gets some knowledge of his accuracy by observing where his round lands. However, this information is seldom formalized, and may be in error due to the difference between the Observer-Target line and the Gun-Target line.<sup>1</sup> There are no aids or devices currently available which attempt to develop skill in distance estimations.

Requirement 5 is concerned with speed of sensing. All service practices are conducted with instructor emphasis on this factor. This emphasis takes the form of oral commands to make sensings more quickly. From observations of service practices it is evident that many students continue to view the target area through binoculars long after the burst has expanded and been blown from its original point of impact. The nature of the observer's activity during this period (between the time of appearance of burst and the report of correction required) is not clear. The observer might make his judgment of location instantly, but keep his glasses on the target area while calculating the correction. Despite the absence of clearcut evidence, it appears safe to assume that observers differ in the speed of their perception of location. There are no aids or devices presently employed which develop skill in this area.

Requirements 6 and 7 are concerned with the ability to use a map effectively in accomplishing the observer's mission. The specific skill required is the ability to relate the terrain viewed to the map of that terrain. The program of instruction in map reading consists of classroom instruction on symbols and representations employed on artillery maps, and a half-day field exercise consisting of (1) traversing a compass course, and (2) practice in locating positions by map. In addition, during the first service practice, the instructor points out target locations on an enlarged map after the students have made their own estimates using their regular equipment. This is an opportunity to relate terrain to map by seeing how a ridge, creek-line, or depression looks from an

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<sup>1</sup>If the target grid is used properly this difference is compensated for and increases or decreases in range will be accurately portrayed.

oblique view as well as from the perpendicular view presented on the map. In view of the considerable importance of map reading, this instruction seems quite brief. Also, it may be unfortunate that map reading instruction and observed fire instruction are not administered by the same department. While emphasis on map reading is great throughout service practices, a certain compartmentalization in the student's thinking is fostered by the fact that he is "finished" with map reading (has been examined in this subject) when he goes on the range for service practices. Aids available include enlargements of maps, perpendicular and oblique aerial photos, and pressed out contour maps. The first two aids are employed with effectiveness. Use of contour maps as an instructional aid was not observed. During this research, the project staff instigated a modification of the OF fan, with the objective of reducing the clutter on the fan so that the map could be seen more easily. A series of tests demonstrated the superiority of initial data computed using this fan over that computed using the previous model.

Requirement 10 refers to the judgment of fire requirements for specific situations. Skill is developed in the training program to the extent that the student is capable of selecting the proper fuze and shell when given a target description by the instructor. However, since the target described bears no relationship to the target perceived (see earlier comments regarding acquisition of targets) there is no practice in relating a seen target to a requirement for a particular combination of fuze and shell.

Requirement 11, selection, occupation and maintenance of the OP, is given introductory treatment in the observed program, further skill to be developed in the post-school phases of training. Since these later phases were not observed, no comments concerning the adequacy of training can be made beyond that inferred from the report that weakness in this requirement is typical of the inexperienced forward observer.

Requirement 13, sensing "own" rounds and discriminating between bursts of various artillery weapons faces the handicap always present in training situations resulting from the need to conserve ammunition. A result is that the students experience is largely confined to (1) the smaller weapons, (2) the less expensive fuzes, (3) short ranges (to conserve tube life). No aids or devices are present which extend the student's range of experience in regard to the visual stimulus.<sup>1</sup>

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<sup>1</sup>Puff-boards and similar training devices are not relevant here, since they are not intended to simulate the visual stimulus. They may be quite adequate in the development of procedural knowledge.

Requirement 14, familiarity with various types of terrain, cannot be adequately developed where training facilities afford a limited variety of terrain features. Training at Ft. Sill, for example, cannot be expected to give the forward observers the visual experiences needed for skill in a typical terrain. Further, it was noted that observers who had developed an adequate proficiency in hilly terrain, made gross errors of estimate when first operating in relatively flat terrain. A means of providing the observers with experience in a wide variety of terrain situations would be a desirable addition to the program, and one for which no training device currently exists.

#### D. Basic psychological skills

The analysis of the job of forward observer, and the analysis of the training he receives isolates certain job requirements which meet imposed criteria of criticalness, and which, in many instances, also constitute training problems. It is for these requirements that the development of training devices seems most amenable.

It is the estimation of the research staff that the most profitable approach to the development of valid training devices is in terms of the more basic skills which account for differences in performance in each job requirement. The recommended device, then, represents a means of developing this skill (or skills) rather than an attempt to duplicate the more superficial aspects of the job. For this reason, an attempt was made to abstract from the list of critical requirements (which constituted training problems) the underlying skills. The following is a list of the required skills, expressed in psychological terms.<sup>1</sup>

The forward observer must be able to:

1. perceive minimal changes in a complex, visual stimulus
2. retain in memory details of a complex, visual stimulus
3. translate available cues into estimations of distance
4. identify typical target objects through form perception

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<sup>1</sup>Some job requirements were too complex to permit analysis into basic skills at the present level of research. These are included in the list for sake of completeness, but retain their original description.

5. perform the above tasks in varying physical settings
6. make a judgment based on the location of a visual stimulus at the instance of its appearance, and resist changing this judgment as the stimulus becomes distorted
7. discriminate between visual stimuli of undetermined similarity, i.e., between bursts of various artillery weapons
8. translate a complex visual stimulus into a specific requirement for fuze action, ammunition, etc.
9. locate relevant points in his sector of responsibility by relating the terrain to a map of the area
10. use his map as an aid to sensing by studying the map to locate areas not visible from the OP.

**E. Trainer for basic visual skills for forward observer and flash observer**

**Objectives**

1. General. The purpose of the basic trainer is to develop certain aspects of perception which underlie successful performance in conduct of observed fire and also flash observation. There are several advantages accruing from a device emphasizing this development. By removing a particular skill from the job situation in which it is found, training may be focused on this one task. In the job complex, the operation of this skill is often obscured by concomitant operation of many other skills. In the job itself, neither the trainee nor the instructor can assess the status of the trainee's learning on this component skill. A device then, gives greater definition to the learning task at the early stages of learning. It is implicit in the above discussion that measurement of learning on a component skill is possible in the device setting, while it is not in the actual job situation. A score based on performance in a complex job is actually a reflection of varying amounts (scores) of a number of underlying skills. In the job performance, the trainee's "score" on each skill is unknown, hence, two learners with identical over-all scores may be quite different in their unknown score pattern. Given a single skill to be learned, identical scores presumably indicate identical

ability on the skill in question.<sup>1</sup> A further advantage of skill development via devices is the reduction of field exercises, since such exercises would, in the device-implemented program, have the status of situation tests wherein skills developed in the basic program would be practiced together.

2. Specific: The particular skills which are to be developed by the basic trainer are:

- a. Identification of objects through form perception
- b. Location in space of visual stimuli
- c. Perception of specified changes in a complex visual field
- d. Retention of details of a complex visual stimulus
- e. Translation of specified visual cues into estimates of distance

#### Stimulus characteristics

1. General. In the following discussion, the term stimulus will refer to specific elements such as a shell burst, a vehicle, a tree, a triangle, or a person. The term stimulus field will refer to the context within which the stimulus appears. The characteristics of the stimulus and stimulus field which follow will specify (1) the variables, and (2) the extent of the variation where this is known. In reality, however, it is this latter specification which constitutes the development program for the device. It is assumed that the vehicle for presenting visual stimuli is readily available in the form of an ordinary slide projector or tachistoscope. What must be developed is the series of stimuli which will lead to effective learning.

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<sup>1</sup>It is recognized that skills identified in the current research are probably not unitary, i.e., not perfectly unrelated. Analyses made possible by gathering scores on the skills isolated may demonstrate the relationships which prevail, and would then suggest a new alignment of skill development. Since such scores cannot be gathered under present training procedures, this would seem to be further argument for the suggested device development.

2. Specific. In raw form, the variables with which we must deal are:

<u>Stimulus variables</u>	<u>Stimulus field variables</u>
a. size	a. brightness
b. brightness	b. contrast effects
c. form	c. complexity
d. color	d. extent
e. position	
f. duration	

These variables must now be considered in the context of the particular skills which are to be developed.

3. Stimuli presented must be identified and located. Stated in terms of underlying variables, the effective form field of the perceiver is to be extended. Considerable research is available here, suggesting (1) that tachistoscopic presentation of stimuli is useful, (2) that simple stimuli such as regular geometric forms are useful in early stages of learning to perceive form, (3) crude divisions of location, such as the four quadrants, are satisfactory for early stages in learning to locate stimuli, (4) a simple uncluttered stimulus field may be used in early stages, (5) that progressive increases in (a) field complexity, (b) specificity of stimulus form, (c) precision of judgment required, should characterize the series of stimuli.

4. Minimal changes in a complex visual stimulus must be perceived. This involves the ability to retain in memory the details of a stimulus field as well as the ability to perceive near-liminal alterations in specific elements of the field. This would require practice with stimuli near the lower threshold (in brightness, absolute and relative to the field; size; color contrast, etc.) for the individual. It would also require that experience be gained with stimulus situations where the change was in terms of an additional element, the deletion of an element, the movement of an element, etc. Provision for testing the retention of details of stimulus fields varying in complexity would be necessary.

5. Monocular cues to distance must be utilized by the perceiver to arrive at an estimate of distance. In the field situation, these cues interact in infinite variations. In the device situation, a cue may be reacted to singly, the operation of other cues being controlled. More difficult stimuli would present various interactions. It is assumed that a two-dimensional (flat) representation of an oblique view is satisfactory for this purpose, but three-dimensional presentation might be investigated in a development phase.

### Response characteristics

1. The nature of the trainee's response is implicit in the preceding descriptions. The trainee is to respond with a judgment of where, what, beyond, in front of, greater than, less than, etc., depending on the skill under development.
2. The recording of responses may be handled by typical paper and pencil instruments. The design of a specific answer sheet is a minor problem given the design of a specific stimulus series.

### Knowledge of performance

It has already been noted that this basic visual skills trainer is not conceived to provide a simulated combat situation. There is no necessity for the trainer to feed back immediately knowledge of performance to the trainee; knowledge of performance will not provide new information that would alter the task of the trainee. It is, however, desirable that knowledge of performance be readily available for reinforcement and motivational purposes.

### Suggested utilization

The basic visual skills trainer is recommended for use in conjunction with the forward observer trainer assessor, the flash observer trainer assessor, and with programs of field exercises. Personnel being introduced to the jobs of forward observer and flash observer could use the trainer to build up basic visual skills as a means of improving performance in more complex training situations. The trainer also could be used to measure visual skills and select those in need of such training.

## F. Forward observer trainer-assessor

### Objectives

The general purpose of this device is to provide a situation where the forward observer may practice the operations involved in his job. As such, the device is a simulator which presents much the same stimulus situation as is presently provided by service practices. The advantages of such a simulator are those which typically result from a device as opposed to a field setting: (a) an objective criterion of performance is more readily obtained; (b) the learning task is more manipulatable by the instructor, which allows the ordering of an effective sequence of practice sessions; (c) a reduction in cost may be effected by reducing the number of field exercises necessary. The simulator here recommended



may also serve as a validation instrument for a basic perceptual skills trainer. It thus represents an intermediate criterion in regard to that device.

The specific training objectives of this device are:

1. to provide a realistic situation for the integration of the basic visual skills demanded by the job
2. to provide practice in acquiring and dealing with realistic targets
3. to develop and apply efficient procedures and skills in map utilization.

#### Stimulus characteristics

The device is to provide the essential elements involved in searching for, acquiring, and fixing upon enemy targets. These elements may be categorized as: (a) those comprising the context (stimulus field) or total situation; (b) those comprising specific targets (stimuli) such as tanks, bunkers, etc.; (c) those comprising shell bursts (bursts) which result from observer conduct of fire. The first two classes of elements are instructor-controlled, the latter is a product of student-observer behavior. All three classes must be "psychologically equivalent" to stimuli present in the actual job situation. The device stimuli must produce the same behavior in the observer as does the field situation. Careful measurement of the functional characteristics of all three classes is required, and the device then designed to reproduce these characteristics. Prior to this measurement, certain requirements appear necessary on the basis of available knowledge.

1. Stimulus field. The device should produce a stimulus field which has the following characteristics:

- a. occupies similar extent (total visual space) to typical zones of responsibility
- b. can be varied in terms of content, color, contrast effects.

2. Stimulus. The device should present stimuli which have the following characteristics:

- a. they can be varied in intensity, form, color, size, contrast with field

- b. a number can be present at any given time
- c. appearance of target stimuli at any location within the field is permitted
- d. movement of target stimuli is permitted, with the duration of their presence a variable.

3. Burst. The device should present shell bursts which have the following characteristics:

- a. bursts can be varied in size, location, color, contrast with field
- b. location must be a function of observer's request for fire.

4. Map. The device should present a standard artillery map representation of the area within which the stimulus field exists.

#### Response characteristics

1. General. The observer is required to search, acquire and identify, and take action against targets which are presented by the device. The stimuli and field are varied to duplicate the essential characteristics of a variety of missions and tactical situations. The difficulty of a task actually presented is to be consistent with the observer's stage of learning.

#### 2. Specific

- a. The observer engages in surveillance. Behavior required by the device corresponds to that required by the actual situation. A means should be provided to encourage systematic search. Information regarding an assumed tactical situation may be provided with a resulting inference concerning possible target locations. The observer should keep a log of all observed activity.
- b. The observer acquires targets. Having observed enemy activity, the observer must locate the activity and report this location in terms of an available reference system. The observer judges the relevance of the activity for the mission assigned to him, and decides on a course of action.

- c. The observer conducts fire. When enemy activity warranting a fire mission is located, the observer may request fire. The observer's adjustment of fire follows the procedure employed in the actual job.

#### Knowledge of performance

In order for the device to be maximally effective as a learning experience, the device must be able to provide knowledge of progress at any time such knowledge would be useful. This means that knowledge may be given following any response (including the behavior of withholding a response). The instructor using the device may critique the observers at any point; for example, after unobserved activity, after an activity has been located (pointing out cues which might have been applied), after any burst in a fire mission, or upon completion of a mission. The device then should include suggestions for presenting knowledge of progress to the observer. These suggestions should include notes on frequent errors, useful cues, rationale for approved decisions concerning missions and the like.

#### Suggested utilization

The forward observer trainer assessor is recommended for all forward observation training programs offered at the Artillery and Guided Missiles School. It is conceived as a supplement to the present service practices offered. It could serve both in the initial learning of the job and in programs designed as "refreshers" for those with previous experience.

## APPENDIX 2: FLASH OBSERVATION

### I. Analysis of the Job of Flash Observer

#### A. Job description

The flash observer is a member of flash ranging platoon which has as its primary mission the location of enemy artillery. Additional duties of the flash ranging platoon include location of targets of opportunity, conduct of individual fire missions, and assistance in registration fire.

The flash platoon operates most effectively when the tactical situation makes it possible to set up a "long base." A long base consists of four observation posts placed in surveyed positions along a line roughly paralleling the front, each post being several thousand yards distant from its neighbor. The observation posts are connected by wire and radio communication to a central plotting station. Necessities of a combat situation may require the use of a shorter base and fewer observation posts. Target locations by a short base are usually less accurate than those determined by a long base.

At each observation post there is a flash observer and three assistants. The observer and his crew are responsible for constant surveillance of their sector of responsibility and for the reporting of details of observed activities to plotting central. The observer may utilize the unaided eye, binoculars, or the M2 observing instrument in his search. When a target is detected, the observer adjusts the M2 so that the target is centered in the optics.<sup>1</sup> Readings are then obtained from the azimuth and vertical scale of the instrument, and are sent immediately to plotting central along with appropriate identifying information. At plotting central the map location of the target is determined through the use of a plotting table utilizing simple geometric principles.

The observer is required to be thoroughly familiar with the terrain in his sector of responsibility. He makes "panoramic" sketches indicating azimuths and distances to prominent points, and "visibility" sketches showing areas masked from his sight. He utilizes a map to aid in his general evaluation of the terrain, as

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<sup>1</sup>Target is used here in a general sense to denote smoke puffs, flashes, air bursts, targets of opportunity, and so forth.

well as to determine reference points and to make visibility sketches. Knowledge of the terrain helps the observer both in searching for targets and in estimating distances to the targets, the latter information being essential in the situation described below.

Plotting central cannot determine the location of a target unless at least two, and preferably three, OP's have reported an azimuth to that target. A major problem in flash observation requires the observers to locate and report data on the same target. Common orientation becomes difficult in a combat situation where numerous targets may be present, and where poor visibility conditions obtain. In addition, many of the targets are often of very short duration as, for example, an artillery flash or a smoke puff.<sup>1</sup> Location by other observers may be facilitated if the first observer to detect the target is able to estimate its distance from the observation post. With this information, plotting central can compute a "looking azimuth" to the target for each of the other observers.

In locating and firing upon targets of opportunity, the flash observer functions in either of two ways. First, he may coordinate his observations with other observers in the manner described above, or he may operate exactly as does the forward observer in conduct of observed fire. The job of forward observer has been discussed in Appendix 1 and will not be reviewed here.

In registration fire the observers are oriented toward the expected point of shell burst. When the burst occurs the M2 observing instrument is carefully adjusted by the observer so that the burst is centered in the reticle superimposed on the optics. Subsequent bursts are reported in terms of their deviation in mils from the center of the reticle, no further adjustment of the instrument being made. Readings are obtained from the calibrations which appear on the reticle.

The above description provides a view of the primary activities of the flash observer. Major attention has been given to the acquisition, or more specifically, the detection, of targets. This has been done since detection is the prime essential of flash observation and all other activities are, of necessity, secondary. From the description of the job of flash observer, certain requirements

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<sup>1</sup>Recent developments in flash and smoke reducing agents successfully minimize the visual cues available to the observer. Universal adoption of these agents may lead to either (a) a change in the present mode of location, or (b) a change in the primary mission of the Flash Platoon.

for the performance of the job may be inferred. These are listed below.

Visual skills are involved in detecting and identifying targets, in evaluating terrain, in estimating distances to targets, and in reading the M2 observing instrument.

Perceptual-motor skills are involved in adjusting the M2 instrument so that the target is exactly centered in the reticle.

Procedural knowledge is utilized in reporting observations to the plotting central and communicating with other OP's.

Map reading skills are utilized in locating reference points, in preparing visibility sketches, in range estimation, and in general evaluation of terrain.

Techniques of search are involved in surveillance of the sector of responsibility.

Knowledge of enemy tactics and equipment is useful in determining the most probable location of targets and in identifying the targets.

#### **B. Application of criteria**

The major job requirements of the Flash Observer were examined to determine the extent to which they constitute critical requirements for training. Three criteria of criticalness were developed: (1) the extent to which the requirement was crucial to the success of the mission, (2) the level of complexity of the skills involved, and (3) the frequency with which the requirement was performed in a substandard manner. A requirement was critical if it was judged crucial, and either complex, or its performances substandard. Table V, page 43, summarizes the application of these criteria to the job requirements.

##### **Criterion 1: Crucial to success of operation**

Flash ranging procedure is initiated with the detection of a target by the observers. Unless visual contact can be made, the flash platoon is inoperative. It is apparent, therefore, that those skills directly related to target detection are most critical in terms of the present criterion. The skills directly involved in detection include visual skills, and techniques of search including persistence in surveillance. The observer must be skilled in the primary aspects of vision, observe the sector in a systematic and efficient manner, and maintain his observations continuously for given time periods.

Other skills contribute indirectly to detection. Map reading skills help the observer to become more knowledgeable about the terrain in his sector. Knowledge of enemy tactics is useful in determining where to look in a given sector. Estimating range to a target, another perceptual skill, is sometimes essential in getting other observers "on" a target once it has been located by one of them. These skills, while important, are not as critical in terms of the present criterion as those listed above.

The observer, having detected a target, must report the OP-target azimuth to plotting central. To obtain the azimuth he must adjust the M2 observing instrument so that the target is exactly centered. Errors in azimuth may lead to inaccurate plots. The perceptual-motor skills involved in adjusting the M2 are therefore critical to the over-all operation. There is, of course, more tolerance for error in this task than in detecting the target in the first place. Errors in adjustment may be compensatory, and since information is ordinarily obtained from at least three observers, individual error may be cancelled out. The azimuth and vertical scales of the instrument must be read correctly, or plots will be made with information basically in error. Such errors would probably be additive rather than compensatory.

Procedural knowledge, while important for smooth operation, is seldom critical to success.

#### Criterion 2: A high level, complex skill

Some of the perceptual tasks required of the flash observer are clearly high level skills. Detection of the target demands that the observer respond to stimuli which:

1. May be small in absolute size and subtend but a minor portion of the visual field
2. Present little contrast to the visual field in terms of color and light
3. Are near the lower perceptual threshold in absolute light intensity value
4. Appear for a very brief period of time

The extent to which detection of stimuli having such characteristics is trainable must be determined by careful laboratory study. However, it is clear that since detection is at the core of flash ranging, these skills should be developed as highly as possible.

Identification of targets demands that the observer, having detected a target, also recognize its form and correlate this with prior experience. The nature of this task varies from the identification of an artillery piece by its flash to the identification of common enemy material in plain sight. In all cases, identification represents a complex skill involving form perception and recognition.

Range estimation is another perceptual task which is a complex skill. When targets are plainly visible, the observer interprets cues of size, perspective, superimposition, shading, etc., to estimate the distance to a target.<sup>1</sup> He is aided in this estimation by his knowledge of the terrain, and his information about prominent landmarks. The observer is often required to make estimations when darkness has obscured the terrain, as in estimating the distance to an artillery piece revealed only by its muzzle flash. Here, such cues as time between the "flash and bang," and silhouette or eclipse of prominent landmarks must be used. Secondary cues, such as the caliber of weapon firing, as judged from its sound, provide some information as to the probable distance.

Search techniques, although apparently simple, actually require fairly highly developed skills. The sector of responsibility includes a much larger area than can be encompassed with a single glance. Effective search requires first that the observer possess basic visual skills, and secondly, that he use systematic scanning procedures. The observer must scan his sector both thoroughly and rapidly so that each part of the field is under continual surveillance. The extent of the observer's visual form field and his speed of perception are important variables in this performance.

Certain aspects of map reading may also be classified as higher level skills. Knowledge of the meaning of symbols, contour lines, guides, measuring distances and directions does not constitute a complex or difficult area to learn. However, relating this information as presented on a given map to a particular terrain may involve several complex skills. More information is needed regarding the exact nature of these skills.

Use of the M2 observing instrument involves certain perceptual-motor skills, as in the adjustment of the optics to center a target in the reticle. When the target is stationary the problem tends to be minimal; however, a moving target (such as a shell bursting in air), or one of very short duration greatly increases the complexity of the task. In the latter case, the problem becomes one of rather precise eye-hand coordination which must be accomplished quickly. Reading deviations of bursts from the center of the reticle (as in registration fire) requires perceptual speed and visual memory.

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<sup>1</sup>Because of the distances normally involved, binocular cues are not useful in making range estimations.



### Criterion 3: Substandard performance

The training situation observed at Ft. Sill did not present an opportunity for extensive observation of the flash observer's performance. Some aspects of the flash observer's job were not available for observation, and others only in somewhat restricted situations. However, certain observations were pertinent, and other information was obtained from interviews with combat experienced personnel.

The most striking performance deficiency was in the acquisition of targets, especially in detecting artillery flashes. In the several night problems observed, the flash observers were largely unsuccessful in detecting the muzzle flashes. Flashless powder was used for these problems, and it is conceivable that the muzzle flashes were not within the visual range. The latter should not be accepted as conclusive until more reliable tests are made.

The interviewees were unanimously agreed that range estimation was generally below acceptable standards. This was apparently a major cause for concern among responsible personnel. This concern stems from the difficulty that observers frequently have in orienting on a common target when multiple targets are present. It was also indicated by the interviewees that map reading performance was commonly sub-par.

TABLE V

Table V summarizes the application of the three criteria of criticalness to the major job requirements of the flash observer. Starred items are considered critical requirements for training.

Job requirement	Criteria		
	Crucial	Complex	Substandard
*1.Acquisition (detection) of targets	yes	yes	yes
*2.Identification of targets	yes	yes	not observed <sup>1</sup>
*3.Estimating distance to targets	yes	yes	not observed
*4.Reading scales of M2 observing instrument	yes	yes	no
*5.Adjusting M2 to center target	doubtful	yes	no
6.Procedural knowledge-reporting observations to plotting central and communicating with other OP's	no	no	no
*7.Map reading - locating reference points, preparing visibility sketches, range estimation and terrain evaluation	yes	yes	yes
*8.Employing efficient search techniques to cover sector of responsibility	yes	yes	yes
9.Knowledge of enemy tactics and equipment	no	no	not observed

<sup>1</sup>These items were either not available for observation or too few instances were available to permit a reliable judgment.

### C. Analysis of training

The training relevant to those job requirements determined as critical in the preceding section was analyzed. Observations were made of two training sequences; the Artillery Flash Ranging Supervision Course (Enlisted) and, the Artillery Observation Officer's Course. The content of the two courses is essentially the same. Neither course is designed to train men specifically for the job of flash observer, but as the titles suggest, they are to train personnel who are to supervise flash ranging operations. The emphasis in the course is on developing a thorough understanding of flash ranging procedures and a familiarity with the jobs performed by personnel in the platoon. Less emphasis is placed on the development of a high degree of skill in any of these various jobs, including that of the flash observer. Since the courses observed were not specifically oriented toward skill development, the statements which follow are not to be interpreted as critical of training in relation to stated course objectives.

Several statements may be made regarding the efficacy of practice relative to critical requirements 8, 1 and 2 (the search, detection, and location of targets), and to requirement 4 (the estimation of distance to targets).<sup>1</sup> This practice occurred largely in the context of field exercises, and may be summarized as follows:

1. There was an insufficient amount of practice for the production of skill in these critical areas. A large portion of the allotted time was required to set up the plotting central and to establish the flash base. The total number of problems presented was small and the intervals in between the problems were often long.
2. The observers were seldom required to search in a systematic fashion for targets in their sector of responsibility. Information regarding target locations was present in the practice situation that would seldom, if ever, be available in combat.
3. A minimum of coordination between observers on the flash base was required. Usually, targets were presented singly so that orientation on a common target by the observers was easily achieved. Therefore, estimation of distance to a target was seldom needed to get the observers "on target," minimizing the amount of practice of this critical activity.

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<sup>1</sup>The critical requirements referred to here are the starred items in Table V, p. 43.

4. The trainees sometimes lost interest in their activities due to certain unavoidable delays in the over-all operation. As a result, they may have failed, in these instances, to profit maximally from the practice.
5. There were no techniques available for objectively evaluating the performance of the observers. Without this evaluation and subsequent connection of errors, skill must be expected to develop more slowly.

The above statements point up certain problems often present in field exercises: limitations in amount of practice and type of problems, lack of complete control by the instructor of the relevant variables, trainee disinterest, and lack of reliable performance measures. Training devices potentially can obviate most of these problems, at least in early phases of training, and at the same time effect certain financial economies.

Requirement 4 refers in part to the sensing of burst deviations during registration fire. The practice afforded during the field exercises was well controlled, although the amount of practice was small.

Requirement 2, identification of targets, refers to the identification of cues revealing the presence of artillery smoke dust, flash, burst patterns, etc. No specific practice was observed other than that inherent in the field problems.

Requirement 5 refers to the alignment of the M2 viewing instrument on a target. The amount and type of practice afforded this activity is apparently adequate, and device implementation does not seem indicated.

Requirement 7 refers to the use of terrain maps in locating reference points and in making visibility sketches. There are universal problems in training personnel to use maps correctly and the present situation was no exception. There was a conscientious attempt to produce the required skills, but in the opinion of those interviewed, current methods were not as effective as desired. The major problems lie not in presenting the basic map information, but in teaching the trainee to relate the terrain to the map. This latter activity, in the opinion of the project staff, requires the development of a number of basic perceptual skills through the use of special training situations, possibly best presented by training devices.

#### **D. Basic psychological skills**

The analysis of the job of Flash Observer, and the analysis of the training he receives isolates certain job requirements which

meet imposed criteria of criticalness, and which, in many instances, constitute training problems. It is for these requirements that the development of training devices seems most amenable. These requirements are expressed below in terms of the more basic skills underlying the performance of each requirement.<sup>1</sup> The devices recommended represent a means of developing this underlying skill rather than duplicating the more superficial aspects of the job.

**The flash observer must:**

1. perceive stimuli in a complex visual field which may be small in absolute size, subtend a very minor portion of the field, appear for brief intervals, present low contrasts, and are near liminal in intensity
2. be able to make a judgment of the location of a visual stimulus of short duration
3. be able to retain in memory details of a complex visual stimulus, sometimes after very short exposure
4. be able to identify typical target objects through form perception
5. be able to translate available cues into estimations of distance
6. be able to perform perceptual-motor acts requiring fine coordination
7. be able to locate reference points in his sector of responsibility by relating the terrain to a map of the area
8. be able to make "visibility" sketches from a map
9. use efficient procedures for searching his sector of responsibility.

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<sup>1</sup>In some instances the complexity of the requirement did not permit its analysis into basic skills. The requirement is included in the list for sake of completeness.

E. Device solutions.<sup>1</sup> Flash  
observer trainer - assessor

Objectives

The general purpose of a flash observer trainer assessor is to provide a situation where the flash observer may practice, in a simulated setting, some of the basic operations required by his job. The advantages to be obtained over field practice are several. First, an objective means of evaluating the observer's performance can be made available, providing a more accurate picture of performance levels and the course of learning than is presently obtainable. Secondly, the task required of the observer is more completely in the control of the instructor, thus the practice sessions may be graduated in amount and difficulty to fit the observer's stage of learning. Third, provision can be made for the inclusion of activities not efficiently trained for the present program. Fourth, the device can substitute for certain of the field exercises, reducing the cost of current training programs.

The specific training skills objectives of this device are as follows:

1. to provide a simulated situation for the integration of the basic visual skills required by the job
2. to provide practice in acquiring realistic targets
3. to develop and apply efficient search techniques
4. to develop skill in the use of the M2 observing instrument.

Stimulus characteristics

The device is to duplicate the essential elements involved in searching for, acquiring, and identifying targets. The elements of the situation may be classified into (a) those visual stimuli which represent the target, and (b) the field or context in which the target stimuli appear. The former will henceforth be referred to as the stimulus and the latter as the stimulus field.

The stimulus and stimulus field provided by the device are to be psychologically identical to those in the actual situation. "Psychologically identical" implies that the device provide a stimulus

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<sup>1</sup>The Trainer for Basic Visual Skills is applicable to the training of the flash observer as well as the forward observer. See discussion of this trainer in Appendix 1, pages 20-36.

complex which affects the sensory receptors of the observer, in this case, visual receptors, as they would be affected in an actual situation. Careful measurement of the various attributes of the stimulus and its field in the natural setting are required and the device should be designed to reproduce these attributes. Such measurement of the stimuli and their fields was not feasible in the present study and of itself constitutes a difficult but not impossible task. The logical first step in the construction of the present device would be to make such measurements as accurately as practical with present equipment and techniques. The attributes of the stimulus and its field which are judged to be important by the investigators are listed below.

The stimulus. The device is to present stimuli which have the following characteristics:

1. The stimuli can be varied in light intensity, form, color and size.
2. Several stimuli can be produced simultaneously.
3. Stimuli can be produced in all portions of the visual field.
4. Duration (temporal) of the stimuli can be varied.

The stimulus field. The device should produce a stimulus field which has the following characteristics:

1. Occupies the same total visual space as does the field in the actual situation.
2. Can be varied in terms of content, light intensity, and color.

The display. The stimulus and the stimulus field should be arranged so that the observer makes the same overt responses as he does in the actual situation. For example, vertical and lateral head movements are to duplicate those required to scan the sector of responsibility.

#### Response characteristics

Trainee behavior. The observer is required to search, acquire, and identify stimuli presented by the device. The stimuli and their field are varied to reproduce the psychological elements of many different targets, terrain, visibility conditions, and so forth. The difficulty of the task in each of the activities is varied to fit the observer's stage of learning. The three activities required of the observer are analyzed below.

Searching behavior. Overt movements required by the device correspond to those made in actually searching a sector of responsibility. A means should be provided to encourage the observer to conduct search systematically. This might be done by requiring him to report the presence or absence of stimuli in sequential portions of the visual field. To expand the form field the subportions of the field could gradually be increased in size, so that the observer learned to take in more and more territory in a single glance.

Acquisition. The observer reports and/or records all stimuli which he detects in his search of the stimulus field. If the M2 observing instrument or its simulator is to be used, the observer is required to adjust the instrument to center the stimulus in the reticle, and he may be required to record an azimuth and declination reading.

Identification. The observer is required to identify the stimulus which comprises the target. Since these stimuli are quite varied, the observer will need to have a great deal of practice in recognition of form and discrimination of form.

Measurement of responses. The observer's responses can be measured in the following ways:

1. Total number of targets detected in a standard sequence.
2. Time required to make a given number of acquisitions.
3. Accuracy of identification.
4. Azimuth and error of a given target.

#### Knowledge of performance

A means should be provided to give the observer a fairly immediate assessment of his performance. In acquisition his attention should be directed to those targets which he has overlooked, so that he may see how they appear. Incorrect search procedures should be penalized and subsequently corrected. It is not necessary for the device to provide immediate knowledge of results to the trainee for the purpose of providing new information which has altered his task.

#### Suggested utilization

The Flash Observer Trainer Assessor is suggested as a supplementary device to be used with the Trainer for Basic Visual



Skills. Its appearance in the training program is ideally soon after the observers have built up their basic visual skills with the basic trainer. The amount of practice required to gain proficiency in searching, acquiring, and identifying targets must be determined by experimental test. To obtain maximum use of the device, it is suggested that it be constructed so several observers may be trained simultaneously, perhaps even as a team.

The Flash Observer Assessor-Trainer, if developed, must be validated by demonstrating that persons trained on the device perform the jobs more effectively than those who have not received such training. The Assessor itself, since it supplies objective measures of performance, can be utilized in the validation of the Visual Skills device, and of the training program for flash observation.

### APPENDIX 3: SOUND RANGING

#### I. Analysis of the Job of Outpost Observer

##### A. Job description

The outpost observer occupies an OP at least two sound seconds (at least 675 meters) closer to the locations of hostile artillery than any microphone in the sound base he activates. In addition, the OP is selected to provide good visual observation of the enemy area, concealment, and to minimize the disturbing sounds of friendly artillery and small arms fire.

The outpost observer is responsible for constant surveillance of his zone. He listens for the sounds of enemy guns or friendly shell bursts which the sound platoon can profitably record, analyze, and locate. He is responsible for starting the sound recording set and stopping it when directed to do so. In addition to activating the sound recording equipment, the outpost observer provides sound ranging central with important information in regard to the sound he has singled out for location. This includes (1) the probable azimuth of the sound source heard, (2) his estimate of the range to the sound source heard, and (3) his identification or estimate of the calibre of the enemy gun he has heard. This information from the outpost observer is important to the sound record reader in enabling him to identify the "pattern of arrivals" of sound waves at the various microphones and consequently leads to a more reliable target location.

The above description provides a focus on those aspects of the outpost observer's job which are most directly concerned with the primary mission of the sound platoon. The focus is restricted to the acquisition of a target which a sound platoon has a satisfactory probability of locating, and of providing information which will make the target location easier and more reliable. No attempt is made in the description to describe situational factors which may affect the job and one's success in it. This has the advantage of directing attention to the basic skills most directly involved in the observer's primary job. Thus, the above description may be rewritten in terms of the skills and knowledge involved.

##### Job requirements:

1. Skill in judging the direction (azimuth) of various sound sources is involved in aiding the sound record reader in visualizing the patterns of arrivals of a selected target.

2. Skill in judging the range of various sound sources is involved in aiding the sound record reader in visualizing the patterns of arrivals of a selected target.
3. Skill in estimating or identifying the calibre of an enemy gun aids in the analysis of the sound tape.
4. Skill in distinguishing between various sounds such as are produced by ballistic waves, muzzle waves, or shell bursts is involved in aiding the sound ranging platoon to select only muzzle waves for analysis.
5. Judgment in the selection of profitable targets for analysis by sound ranging methods aids the efficiency of the platoon.
6. Knowledge of sound ranging procedures facilitates selection of targets for analysis.
7. Knowledge of the characteristics of enemy artillery and its employment aids in knowing the probable types of fire expected from various locations.
8. Map reading skills are utilized in the evaluation of terrain in terms of probable artillery locations.
9. The ability to select and occupy an OP is required to obtain good visual observation, concealment, and to minimize the disturbing sounds of friendly artillery and small arms fire.
10. Ability to detonate an explosive if a base is to be "shot in" is required.

## **B. Application of criteria**

### **Criterion 1: Crucial to success of operation**

Requirements 1-4 are perceptual skills, all of which are critical to success. A failure in any one of these seriously endangers the probability of locating an enemy gun by means of sound ranging. A large error in judging the direction of a sound source increases the difficulty of visualizing the correct pattern of arrivals of sound waves as they are recorded on the sound tape. Poor judgment of gun calibre would produce error in estimating range and consequently increase the difficulty of reading the sound tape. Confusion of a ballistic wave for a muzzle wave, of course, would result in erroneous information to the sound ranging central.

Requirement 5, the selection of profitable targets for analysis, is critical to success. A wise selection of targets makes the tasks of others in the sound platoon ones that can be accomplished. A poor selection leads to failure of the platoon to locate the target.

Requirements 6 and 7, involving knowledge of sound ranging procedures and the characteristics and employment of enemy artillery are crucial to success. Knowledge of sound ranging procedures would promote the wise selection of targets for analysis, and would aid the outpost observer acquiring and passing on the kind of information that would aid others in the sound platoon. Knowledge of enemy artillery (types of guns and employment) would aid in estimating range to a selected target and in identifying gun calibre. The accuracy of these judgments would, of course, aid others in identifying the pattern of arrivals on the sound tape, and in identifying the wave form of a particular gun.

Requirements 8 and 9, map reading skills and the task of selecting and occupying an OP, are of doubtful criticalness. Inability or poor performance in either of these requirements does not establish a high probability of mission failure. The kind of estimates of azimuth and range provided by the outpost observer do not require or permit the pinpointing of a target location on a map. The selection of an OP can be made by the platoon leader to increase the probability of mission success.

Requirement 10, the "shooting in" of a base, is of doubtful criticalness. This particular method is only a substitute when satisfactory maps are not available, or when the terrain makes other survey methods difficult or impossible.

#### **Criterion 2: A high level, complex skill**

In respect to this criterion, the perceptual abilities involved in the job, requirements 1-4, are high level, complex skills. Research in sound localization has established that individuals vary in their skill in estimating direction and distance of a sound source. These skills do not appear to be simple ones which are mastered in a few practice sessions. Similarly, identification or estimation of gun calibre from its sound, and discrimination between ballistic and muzzle waves are not skills easily acquired through combat experience. Combat experiences with these sounds does not commonly lead to skill in identifying and discriminating between them.

It should be noted that the stimulus presented to the observer can be quite varied and complex. First, it can originate over a fairly wide lateral range, and over considerable depth in range. The wider the variety of guns employed by the enemy, the more complex the stimuli become. In addition, distracting sounds (ballistic waves, shell bursts, other guns and small arms fire) accompany the stimulus to complicate the observer's task.

Requirement 5, selection of profitable targets for analysis, involves judgment of a complex nature. The judgment involves the selection of a target that has a high probability of being successfully analyzed by sound ranging; all the factors bearing on this probability must be considered in making the judgment.

Requirements 6, 7, 8, 9, and 10 are either not complex skills or of doubtful complexity. Knowledge of sound ranging procedures and knowledge of the characteristics of enemy artillery and its employment represent information possessed by the observer. As such, this information can be taught in the classroom and measured through the use of traditional classroom tests. Requirement 8, map reading skills, is of doubtful complexity in the case of the outpost observer. His job does not require the use of a map to pinpoint target locations; he uses a map largely to determine the general and probable location of targets. The pinpointing of the target results from the use of the sound equipment. Requirements 9 and 10, selecting and occupying an OP and "shooting in" a base are not complex skills.

### Criterion 3: Substandard performance

This third criterion suggests the following when applied to the perceptual skills involved in this job (requirements 1-4). The field exercise for the outpost observer provides no training or measure of his skill in identifying enemy guns. Second, the guns employed tend to be those of smaller calibre; this is done to reduce training costs. Thus, no measure of performance is possible in respect to the observer's skill in estimating gun calibre. Occasionally, TNT is used to simulate the gun; this makes a measure of the auditory perceptual skills of the observer unreliable. In summary, the field exercise provides no satisfactory measure of performance, and very likely is not adequate to train the observer in the perceptual skills needed. At the same time, combat veterans with experience in this job report that these skills are commonly substandard in the combat situation.

Requirement 5, selecting profitable targets for analysis, is not trained for or measured in the field exercise. The observer's task is oversimplified in that only one gun, or guns from one sector are fired at a time. Again, combat veterans report that wise selection of targets is commonly substandard in the combat situation.

Requirement 6, knowledge of sound ranging procedures, was observed in the few instances available. Trainees seemed to be adequately informed on sound ranging procedures.

No reliable appraisal of the quality of performance can be made in respect to requirements 7, 8, 9 and 10. These performances were either not required in the training program, or there were too few instances of the performances to permit a judgment. (For Requirements see Table VI.)

TABLE VI

This table presents the evaluation of the job requirements of the sound observer. Starred items are considered critical requirements for training.

Task	Criteria		
	Critical	Complex	Substandard
* 1. Judging the direction (azimuth) of various sound sources	yes	yes	not observed <sup>1</sup>
* 2. Judging the range of various sound sources	yes	yes	not observed
* 3. Estimating or identifying the calibre of an enemy gun	yes	yes	not observed
* 4. Distinguishing between various sounds such as are produced by ballistic waves, muzzle waves, or shell bursts	yes	yes	not observed
* 5. Selecting profitable targets for analysis by sound ranging methods	yes	yes	not observed
6. Knowing sound ranging procedures	yes	no	no
7. Knowing characteristics of enemy artillery and its employment	yes	no	not observed
8. Map reading skills	doubtful	doubtful	not observed

TABLE VI (continued)

Task	Criteria		
	Critical	Complex	Substandard
9. Selecting and occupying an OP	doubtful	no	not observed
10. "Shooting in" a base	doubtful	no	not observed

<sup>1</sup>In the observed training program, these performances were either not required or too few instances of the performances were available to permit a reliable judgment.

#### C. Evaluation of training -- outpost observer

Requirement 1 -- ability to perceive the direction of a sound source: The field exercise involves certain disadvantages in the training of this skill. First, for safety reasons, guns are not located to the front of the outpost observer and fired toward him; range limitations occasionally prevent the guns from being placed to the observer's front and fired laterally to his OP. Secondly, as the trainee becomes familiar with the ranges, he is apt to know in advance the location (and direction) from which rounds will be fired. No aids or devices which offer this training in perceiving direction are currently available.

Requirement 2 -- ability to estimate the range of a sound source: Several factors interfere with the field exercise being a superior training experience in this requirement. First, cost considerations reduce the use of large calibre guns which, in combat, would be located at greater ranges than small calibre guns. Second, the guns that are used are not realistically located in terms of probable enemy artillery tactics; guns are located at "approved and established" gun positions on the ranges. These positions may be "wrong" in terms of calibre and typical methods of employment. Third, these "approved" gun positions become known to the trainee and his judgment of range is influenced. No aids or devices offering this training are currently available.

Requirement 3 -- ability to identify or estimate the calibre of enemy guns upon hearing their muzzle waves: The service practice does not, and probably cannot, employ enemy guns to train outpost observers. The guns that are employed, due to cost considerations, tend to be those of light and medium calibre. Consequently, training in this requirement is handicapped.

Requirement 4 -- ability to distinguish between various sounds such as are produced by ballistic waves, muzzle waves, or shell bursts: Due to cost considerations, TNT is occasionally used to simulate artillery fire. This, of course, provides no training in this requirement. When guns are used, the shell burst does not occur to the front of the observer as would frequently be true in combat. This safety precaution may oversimplify the training situation.

Requirement 5 -- ability to select targets wisely for analysis by sound ranging methods: The present training program does not present the trainee with several possible targets from which he must make a selection; one gun or guns from one firing point is all that is presented at a time. This again is likely the result of cost problems. The battlefield sound situation does not appear possible in the field exercise. No training aid or device is currently available to provide this training.

#### D. Basic psychological skills

In order to consider device development for the critical job requirements of the outpost observer, the basic psychological skills involved in these requirements were abstracted.

##### Basic psychological skills.

1. Sound localization: Ability to render a judgment of optimum accuracy on the direction of a sound source.
2. Sound localization: Ability to estimate with optimum accuracy the range of a sound source.
3. Auditory discrimination: Ability to identify or estimate the calibre of various guns upon hearing their muzzle waves.
4. Auditory discrimination: Ability to distinguish between various sounds such as those produced by ballistic waves, muzzle waves, and shell bursts.
5. Judgment: Ability to select targets wisely for analysis by sound ranging methods.



**E. Recommended device for sound outpost  
observer -- sound outpost observer trainer**

**Objectives**

**1. General:**

- a. to provide objective measures of job performance in the critical aspects of the job
- b. to provide the means of presenting training materials in a basic auditory skills training program and/or in a combat simulated setting
- c. to provide a validation instrument for basic auditory skills training.

**2. The skills to be developed are:**

- a. sound localization: ability to render a judgment of optimum accuracy on the direction of a sound source
- b. sound localization: ability to estimate with optimum accuracy the range of a sound source
- c. auditory discrimination: ability to identify or estimate the calibre of various guns upon hearing their muzzle waves
- d. auditory discrimination: ability to distinguish between various sounds such as those produced by ballistic waves, muzzle waves, and shell bursts
- e. judgment: ability to select targets wisely for analysis by sound ranging methods.

**Stimulus characteristics**

1. General: In general, the stimuli to be presented are chiefly auditory. Visual stimuli needed are maps of terrain and views of terrain.

2. Target stimulus: The target to be acquired and located is the sound produced by the muzzle wave of an artillery piece. The device should be capable of providing the sounds produced by various guns, in particular those likely to be employed by "enemy" artillery.

The device should be capable of presenting sounds which appear to or have originated from roughly 3000 to 15,000 yards from the observer, and originate in a sector covered by an 800 mil angle to his front.

In order that the stimulus be psychologically "true" to the trainee, it should have the following characteristics: First, the phase differences of the stimulus to the two ears must be accurate. Second, the binaural time differences of the stimulus in arriving at the two ears must be accurate. Third, it is probable that the intensity differences and distance differences of the stimulus to the two ears are negligible for low frequency tones arriving from distances involved in outpost observer training. Fourth, the stimulus when presented to the trainee's ears must possess the characteristic of externalization; that is, its location or origin must not appear to be inside or near the head. It must be externalized properly in space. Fifth, the sound stimulus must be accurately presented to the trainee in respect to frequency, amplitude, and wave composition.

3. Stimulus field: The auditory setting in which the stimulus is presented should possess the following characteristics. The field should contain the audible sounds which accompany a muzzle wave, such as the ballistic wave and shell burst. Secondly, the device should be capable of presenting a field ranging from simple to complex in respect to the number of enemy guns firing from various locations and the number of distracting sounds such as friendly artillery and small arms fire.

The device should be capable of presenting or withholding the visual field or view of the terrain as seen from the observer's OP. This view need not exceed an 800 mil angle to the observer's front.

#### Response characteristics

Four responses are required of the trainees. First, the trainee selects a target among those heard for analysis by sound ranging method. The device should be capable of recording the selections made. Second, the trainee makes a judgment of the direction of the sound source; the response should be expressed in mils. Third, the trainee estimates the range of the sound source he has heard. Fourth, the trainee identifies the enemy gun or estimates its calibre at least to the extent of classifying it as light, medium, or heavy.

### Knowledge of performance

In terms of training objectives, there is no interaction between stimulus and response (trainer and trainee) required. The device need not feed back immediate knowledge of performance to the trainee. Such knowledge of performance would not be consistent with the combat situation. It would be desirable, however, for the device to provide knowledge of performance for reinforcement and motivational purposes.

### Suggested utilization

In addition to the device uses discussed, one special use should be noted. It appears likely that the recommended device could be employed in team training of several members of the sound ranging platoon. Specifically, the device could present sound sources of known location to the outpost observer. Sound record tapes of the same stimuli could be made for training of the sound record reader. The contribution of the work of the outpost observer to the work of the sound record reader and later the sound ranging plotter could be demonstrated. The integration of these three functions, in a training situation, is a use of the device worth consideration.

## II. Analysis of the Job of Sound Record Reader

### A. Job description

When the outpost observer selects a sound for analysis by sound ranging methods, he signals the operator of the sound recorder. The sound recorder produces a tape which records the arrival time of the sound at the various microphones in the sound base. A pattern of arrivals is thus produced on the tape. In addition to the arrival time of the sound at each microphone, the recorder produces a record of the characteristics of the sound in terms of amplitude, frequency, and wave composition. This record (tape) is turned over to the sound record reader for analysis and interpretation.

Selection of the desired pattern of arrivals (breaks) is the first step in reading a record. If there is only one pattern, this is a simple task. When there are several sounds recorded on the tape, and consequently several patterns, the reader must visualize the desired pattern in order to isolate it from other patterns. Having isolated a pattern for study, the record reader then attempts to determine the time of the initial break for each trace; a trace will appear on the sound tape for each microphone in the sound base.

The problem of determining the initial break in each trace is complicated by the fact that various conditions such as wind interference affect the styli that produce the traces. When initial breaks can't be identified, other points on the wave form are used; these commonly are first valleys, first peaks, and zero lines of the wave forms.

After a set of arrival times have been determined for a given sound, the record reader has the task of inspecting the wave forms selected, to interpret them, and extract information. He attempts to judge the calibre of the gun firing from the wave amplitude and frequency. He attempts to distinguish the wave forms of different types of guns. He must be sure he hasn't selected ballistic wave forms or the wave forms produced by shell bursts; these need to be distinguished from muzzle waves.

The above description may be rewritten in terms of the skills and knowledge involved.

#### **Job requirements:**

1. The ability to distinguish the wave forms produced by ballistic waves, shell burst, and muzzle waves.

2. The ability to identify and locate breaks in sets of traces.
3. The ability to visualize the pattern of arrivals from information given by the outpost observer.
4. The ability to visualize the approximate wave form from information given by the outpost observer.
5. The ability to estimate gun calibre from the wave frequency (period).
6. The ability to determine the time of the initial break (or other selected point) for each trace.
7. Experience with a particular sound ranging set.

#### B. Application of criteria

##### Criterion 1: Crucial to success of operation

Requirement 1, distinguishing between wave forms is crucial to success. If the wave forms produced by the ballistic wave or shell burst are confused with the desired muzzle wave, the resultant plot is bound to be in error, and the location of the sound source is not accurately ascertained. Sound plotting methods assume that the sound originates at a fixed source; it is only the muzzle wave that originates at the location of the gun fired. The ballistic wave may originate at various points in the shell's trajectory. The wave produced by the shell burst, of course, does not locate the position of the gun.

Requirement 2, identification of breaks, is crucial to success. Every error in fixing the point of break results in plotting errors. This produces a large polygon of error and consequently the estimate of the accuracy of a location by sound ranging methods cannot be precise.

Requirement 3, visualizing patterns of arrivals, can often be vital to success. If only one or two guns have fired, the sound tape may be fairly easy to read. On the other hand, when the sound tape includes numerous arrival patterns and other distracting waves or waverings, the ability to visualize the pattern one seeks becomes important. Lack of this ability is quite apt to result in complete failure.

Requirement 4, visualizing the wave form sought, is crucial to success. Similar to requirement 3, the ability to visualize the approximate wave form one should get on a tape is important to success in finding a pattern of arrivals on a complicated sound tape.

Requirement 5, estimating calibre from wave frequency, is of doubtful criticalness to success. A measurement of the recorded period of a wave is only an aid in estimating calibre. Only smooth, typical gun waves, free of distortion, are useful for this purpose. Even under these restrictions, the recorded periods will vary for guns of the same calibre, due to variations in gun design, powder charges, weather, distance. Thus, specific weapons cannot be identified with great confidence, but guns can be classified as light, medium, or heavy. If the record reader, by means of this skill, can provide a rough classification of gun calibre, this can be useful to intelligence and to those deciding if the target is a profitable one.

Requirement 6, determining arrival times, is crucial to success. Errors made in this matter result in plotting errors, which in turn lowers the accuracy with which the location of a target may be estimated. The more vague the estimate of target location the less profitable the target becomes.

Requirement 7, experience with a particular sound ranging set, is of doubtful criticalness to success.

#### Criterion 2: A high level, complex skill

Requirements 1, 2, 3, 4, 5, and 7 represent complex skills. One cannot be expected to master any one of these skills in a few practice sessions. Secondly, it is apparent that these abilities represent something more complex than the possession or understanding of information. The making of fine discriminations, the visualizing of expected patterns, the making of judgments from complicated, incomplete, and distorted data, and knowing the peculiarities of a particular sound ranging set suggest that such abilities are not easily acquired.

Requirement 6, determining arrival times, is simplified as a task through the aid of record readers. Adequate skill can likely be attained in a relatively few practice sessions.

### Criterion 3: Substandard performance

The application of this third criterion was not as complete as would be desired. Training sessions in tape reading were not available for observation during the field study. In the observed field exercises only one firing point was active at a given time; this resulted in tapes that were easy to read. Performance under complex conditions was not observed. However, the following suggests that performance in tape reading is often substandard. Veterans with combat experience in sound ranging platoons report that failures in making accurate locations are commonly due to errors introduced during the tape reading phase. The steps which follow tape reading, plotting and computing, are more easily checked for errors. (For Requirements see Table VII.)

TABLE VII

This table presents the evaluation of the job requirements of the sound record reader. Starred items are considered critical job requirements.

Task	Criteria		
	Critical	Complex	Substandard
*1.Distinguishing the wave forms produced by ballistic waves, shell bursts, and muzzle waves	yes	yes	not observed <sup>1</sup>
*2.Identifying and locating breaks in sets of traces	yes	yes	doubtful
*3.Visualizing the pattern of arrivals from information given by the outpost observer	yes	yes	not observed
*4.Visualizing the approximate wave form from information given by the outpost observer	yes	yes	not observed
5.Estimating gun calibre from the wave frequency (period)	doubtful	yes	not observed
6.Determining the time of arrival of each break	yes	no	doubtful
7.Knowing, through use, a particular sound ranging set	doubtful	yes	not observed

<sup>1</sup>In the observed training program, these performances were either not required, oversimplified, or too few instances of the performances were available to permit a reliable judgment.



### C. Evaluation of training - sound record reader

Requirement 1 -- ability to distinguish various wave forms: A library of sound tapes is used for part of this training. Trainees are given practice in distinguishing ballistic, shell burst, and muzzle waves. In the Ft. Sill situation, classroom use of this library is an aid to the training program. It is not known if similar libraries exist where non-resident training is carried on. It is also not known if the sound sources recorded on the tapes used are known. Such knowledge would serve to test and appraise student skill. No indication was found that the library of tapes have been arranged in a graded series for maximum training benefit. Field exercises using TNT are inadequate for training in this requirement.

Requirement 2 -- ability to identify and locate breaks: The field exercises observed are inadequate for training in this requirement. Tapes resulting from field exercises typically record the firing of one gun. The problem of locating breaks has been simplified; adequate performance at this level would not be adequate for combat conditions. The sound tape library serves a useful training function in this requirement. There appears to be no reason why training in this requirement can't largely take place in the classroom or non-field training session.

Requirements 3 and 4 -- ability to visualize the pattern of arrivals and expected wave forms from information given by the outpost observer: It appears that training in these requirements could be given principally in the classroom setting. All that is required is the sound tape and the information from the outpost observer. This does not require the field exercise except as an experience in coordination between two jobs.

### D. Basic psychological skills

In order to consider device development for the critical job requirements of the sound record reader, the basic psychological skills involved were abstracted.

#### Basic psychological skills:

1. Visual discrimination: Ability to discriminate between similar stimuli (wave forms produced by muzzle, ballistics, and burst).
2. Visual perception: Ability to identify stimulus component (break in wave).

3. Visualization: Ability to visualize stimuli which would result from a specific source (pattern of arrivals).
4. Visualization: Ability to visualize stimuli which would result from a specific stimulus (wave forms of various guns).

E. Recommended device for sound record reader - sound record reader trainer

Objectives

1. General:

- a. To provide for the reproduction of a graded series of tapes for use at installations which are without the means of producing such a set of training materials.
- b. To permit the development of sound tapes using the guns of potential enemies.
- c. To permit, if desired, the development of sound tapes made in coordination with materials developed for the outpost observer trainer, thus permitting the integration of training for these two jobs.
- d. To provide objective measures of job performance in the critical aspects of the job.

2. The skills to be developed are:

- a. Visual discrimination: Ability to discriminate between similar stimuli (wave forms produced by muzzle, ballistics, and burst).
- b. Visual perception: Ability to identify stimulus component (break in wave).
- c. Visualization: Ability to visualize stimuli which would result from a specific source (pattern of arrivals).
- d. Visualization: Ability to visualize stimuli which would result from a specific stimulus (wave forms of various guns).

### Stimulus characteristics

1. General: In general, the stimuli to be presented are chiefly visual in the form of sound tapes. Information from the outpost observer could be presented visually or audibly.

2. Target stimulus: The targets (figures) are the tracings produced by four or more styli on a sound tape. The tracings represent the impact of the muzzle wave of a selected enemy gun on four or more microphones in a sound base. The device should be capable of producing sound tapes identical with those produced by the operational equipment used for the same purpose. In addition, it should be possible to make numerous undistorted copies of any tape produced.

3. Stimulus field: The visual setting in which the stimulus is presented may contain ballistic waves, the waves produced by shell bursts, the waves produced by other guns (enemy or friendly), the waverings due to wind and any other sound that may be picked up by the microphones. The device should record these sources of waves or waverings in the same way that operational equipment would.

### Response characteristics

Four responses are required of the trainee. First, from the information furnished by the outpost observer, the trainee reports what pattern of arrivals he visualizes. Second, from the information given by the outpost observer, he reports what approximate wave form he visualizes and seeks. Third, he locates the proper pattern of arrivals on the sound tape. Fourth, he selects a set of breaks on the sound tape.

### Knowledge of performance

In terms of training objectives, there is no interaction between stimulus and response (trainer and trainee) required. The device need not feed back immediate knowledge of performance to the trainee. Such knowledge would not provide additional cues to the trainee for the accomplishment of his task. It would be desirable, however, for the device to provide knowledge of performance for reinforcement and motivational purposes.

### Suggested utilization

The primary values of the device are (1) it permits the development of a graded series of sound tapes for training, (2) it could permit the development of sound tapes using enemy guns and stimulus fields more like those experienced in combat, and (3) it permits a more organized and complete training in these requirements for non-resident installations which may not have the means of producing sound tapes.